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Are medical students interested in research? – students' attitudes towards research

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ABSTRACT

Background: Throughout the years significant progress has been observed in all medical fields. It was possible to achieve thanks to a wide range of scientists, including physician-scientists. However, in recent years their number is significantly declining. Thus we have aimed to explore the attitudes of medical students towards research.

Methods: The cross-sectional study was conducted among medical students of Medical University of Warsaw between the 1st and 23rd of December 2019. Survey examining scientific interests and activities, opinions on selected research issues, and perception of potential barriers to research activities has been distributed to 838 students and collected from 695 (391 students of the 2nd year and 304 of the 5th year) with a response rate of 82.9%. Descriptive statistics, the Chi-squared test, U-Mann–Whitney, and Kruskal-Wallis tests were used for between-group comparisons. The differences were considered statistically significant if the p values were $<.05$.

Results: 55.2% of responders rated their scientific interests in high school as high, with no significant differences between 2nd and 5th-year students. 33.8% ($n = 233$) of all students plan to pursue research activity after graduation, and 52.8% ($n = 360$) plan to obtain PhD title. Students who presented higher scientific interests in high school more often were involved in research projects at the university (24.7% vs 17.5%, $p = .044$), and showed higher interest in pursuing a research career (37.9% vs 28.9%, $p = .02$). Lack of time and knowledge on starting a research project were perceived as the main barriers to scientific work.

Conclusions: Many medical students express research interests, are involved in scientific projects, and plan to pursue their careers in this direction. There is a majority of students with lower attitudes towards research. Medical universities should consider adapting their curricula accordingly to accommodate the needs of both groups and respond to the shortage of physicians working in clinics and research.

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KEY MESSAGES

- One-third of medical students plan to pursue career in medical research after graduation.
- Students who presented higher scientific interests in the high school are more often involved in research projects at the university and show higher interest in pursuing a research career.
- According to medical students, lack of time, resources and funding and insufficient knowledge how to start a research project are the most important barriers to research activity.

Abbreviations: MD PhD: The Doctorate of Medicine and of Philosophy; MUW: Medical University of Warsaw; PhD: Doctor of Philosophy

Background

The area of health-related research is constantly growing and becoming an increasingly multidisciplinary endeavour. This requires efforts from a wide variety of researchers, including biologists, pharmacologists, geneticists, and physicians. Physician-scientists are necessary to link basic science research and clinical practice successfully. A significant advantage of

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Supplemental data for this article can be accessed here.

including clinician-scientists in the research teams is their ability to identify patient-focused problems, distinguish clinically helpful information, and then address it with high-quality basic science [1,2]. Clinician-scientists can better identify the research priorities, considering their possible impact on patient care. Moreover, such an approach can lead to a more sustainable allocation of resources and reduction of research waste.

Unfortunately, the number of physician-scientists is constantly declining [3]. In the US, the proportion of physicians engaged in research has declined from 4.7% in the 1980s to approximately 1.5% nowadays [2,3]. Recently, prominent scientists, including Nobel Prize laureates, have underlined a need for urgent actions to increase the participation of medical doctors in research [2].

Research careers can develop at several points along the educational continuum. Initial scientific interests can be formed at pre-university; however, they are usually catalysed during medical studies. It has been shown that students who were exposed to research opportunities at universities are more willing to obtain a PhD (Doctor of Philosophy) and pursue a scientific career [4,5]. However, medical school curricula have numerous conflicting priorities, usually placing clinical medicine and practical skills as the critical priority over research activities. Research-associated topics are generally considered additional issues, often offered as elective rather than compulsory courses. Some universities have developed dedicated programs, such as Medical Scientist Training Programs or MD PhD Programs, offering students a more profound research experience [4,6–8]. Until recently, no structured program has been applied at the Medical University of Warsaw (MUW); however, a student scientific movement at MUW has started in the early 1950s. First student scientific groups were formally established and associated in Students Scientific Association of Medical University of Warsaw during that time. Student Scientific Groups, a form of student interest groups that are officially recognised and registered by MUW authorities are organised in almost all departments and supervised by experienced researchers. Since the 1950s, university authorities have identified and supported research activities conducted by students. Various forms of support, such as research grants, scholarships, and conferences, have been provided, leading to the constant growth of this scientific movement. Currently, there are over 200 various groups that offer extracurricular activities in the area of clinical practice as well as basic, translational, and clinical research.

Until recently, no formal education in terms of research methodology had been offered at MUW, but since 2018 a new subject called "research methodology" (a 30-h obligatory course) is also taught to medical students. In 2020, the first edition of the MD PhD (The Doctorate of Medicine and Philosophy) program was introduced. The program allows a small group of medical students in their last years (5th and 6th year) to combine medical studies and conduct a research project. Graduates of MD PhD program receive both MD and PhD degrees.

A growing number of research opportunities for students has been recorded in recent years at Polish medical universities. However, we hypothesise that with no formal education preparing students for conducting well-designed research, there is a high risk of abandoning the research field after graduation. Students' scientific interests and activities have not been formally studied before in the population of polish students. Several studies, mainly from the US, India, and Arab countries, have analysed students' attitudes towards research and their involvement in research projects at university [9–18]. It has been reported that around 20–50% of medical students were involved in research activities during medical school, but their attitudes differed between different programs, years of studies, or inclusion of compulsory research courses in the curriculum [9,17]. Various barriers limiting research endeavours have also been proposed, such as lack of time, the priority of education over research, or inadequate training in research methodology [9,11,12,18].

Significant variability in attitudes towards research was described for students from different countries, but such a study has not yet been conducted in Poland. Thus, we developed a study that aimed to examine medical students' research experience and attitudes at the Medical University of Warsaw. We also aimed to explore the perception of potential barriers limiting student participation in research projects. It is important to understand how students perceive scientific careers, to better tailor the university curriculum, provide adequate education in research methodology, if needed, and offer an optimal environment for further personal development as a scientist.

Materials and methods

Study design

The cross-sectional study has been performed among 2nd and 5th-year medical students of the Faculty of

Medicine of the Medical University of Warsaw between 1st and 23rd of December 2019 (3rd month of the academic year). 2nd-year students were chosen for the study as representatives of students at the beginning of the university and 5th-year students as more experienced students who had completed four years of studies and had enough time to clarify their interests. Participation was entirely voluntary, and confidentiality was preserved at all stages of the study since survey was anonymous and no personal information was collected and stored. According to the study's national regulations and noninterventional character, ethical approval was not required [19]. According to national law, verbal informed consent was obtained from all study participants, which is a standard procedure in this type of noninterventional study [19].

Study rationale

The general education system in Poland consists of three main levels: primary school, high school, and university level. Nearly all students who choose medical studies enter the university directly after high school. Medical studies last six years, with first 2 years dedicated mainly to preclinical subjects (such as anatomy, physiology, pathology). Clinical skills are introduced at 3rd year. Further clinical rotations continue from 3rd to 6th year. Research methodology introduced to the curriculum in 2018 for the 2nd year students and lasts 30 h. By the time of the study, none of the participants have completed the course. Besides research methodology, there is no other subject in the curriculum dedicated directly to the research topics. Students who express scientific interests can fulfil them during extracurricular activities, mainly in Student Scientific Groups. Based on our observation of the increasing number of students engaged in multiple research activities, we hypothesised that providing a favourable research environment at university may increase the number of physician-scientists. Thus, a specific survey was designed to assess students' attitudes towards research and evaluate their involvement and performance in scientific projects.

Instrument

Students have received a paper survey consisting of 38 questions. Questions have covered issues related to interests expressed in high school, motivations for choosing medical studies, research interests and activities at university, and plans for a future career. Moreover, the last part of the survey has examined students' opinions on selected scientific issues and potential barriers limiting their involvement in research activities. The survey was written in Polish and took ten to fifteen minutes to complete. Section about the opinion on selected research issues and perception of potential barriers to research activities consisted of 10 and 13 questions – statements that students were asked to rate on a Likert scale from 1 to 5. The survey was developed specifically for this study and was based on previous experience and available literature from similar studies [9]. Before the study, the survey was assessed by lecturers and students collaborating with our Department. The questions were assessed the survey in terms of questions clarity and understandability – comments and suggestions were used to develop the final version of the survey. Formal validation of the survey was not performed. The English version of the survey is available as supplementary material.

Data collection procedure

Students were contacted before lectures and invited to participate in the study by representatives of authors (J.D., N.B.). Each student received a printed copy of the survey and received enough time to fill in the form. Later, completed surveys were collected anonymously, and data were put into the electronic database.

Data analyses

Discrete variables were summarised as numbers and percentages, continuous ones – with mean and standard deviation in case of a normal distribution or with median and interquartile range when distribution was skewed. For ease of reporting the Likert scale (for questions about the opinion on selected research issues and perception of potential barriers to research activities), descriptive results responses of 4 and 5 were grouped and reported as agreements, 1 and 2 as disagreements, while three were considered as neutral. Quantitative statistics utilised the full 5-point Likert scale. The Kołmogorow-Smirnow test, analyses of median, skewness, and visual interpretation of histograms were used to assess normality. The Chi-squared test, Mann–Whitney U, and Kruskal-Wallis tests were used for between-group comparisons. All analyses and figure drawings were performed using IBM SPSS Statistics for Windows version 26 (IBM Corp). The differences were considered statistically significant if the p values were $<.05$.

Results

General characteristic of the population

Surveys were delivered to 838 students (all 2nd and 5th-year students). The response rate was 82.9%, and final analyses were conducted on a group of 695 students (391 students of the 2nd year – response rate 88.8% and 304 of the 5th year – response rate 76.4%). The demographic characteristics of the participants are presented in Table 1. There were no significant differences between 2nd and 5th-year students in terms of gender, high school location, nor access to extracurricular activities in the high school (Table 1).

High-school interest in research

Majority of responders, 55.2%, rated their scientific interests in high school as high, with no significant differences between 2nd and 5th-year students (58.2% vs 51.3%, $X^2 = 4.61$, df $= 2$, $p = .101$). Paricipation in National Olympiads for high school students, was substantially lower among with 2nd-year in comparison with 5th-year students (38.2% vs 42.9%, $X^2 = 19.66$, df $= 1$, $p < .001$).

The percentage of students who considered research possibilities when applying to medical school was greater in 2nd-year compared to 5th-year students (59.4% vs 39.5%; $X^2 = 35.05$, df $= 2$, $p < .001$). Scientific possibilities as the main reason for pursuing medical studies were the third most common reason among 2nd-year (13.6%) and fifth among 5th-year students (6.3%). The main motivations were willingness to help others and financial stability.

Research interests and activities during studies

The majority, 69.0% of 2nd-year and 81.9% of 5th-year students ($X^2 = 15.02$, df $= 1$, $p < .001$), were involved in the activities of student scientific groups. Only a minority of students were active in such groups during the 1st year at university (6.0% vs 5.3%, $X^2 = 0.146$, df $= 1$, $p = .742$). Thirty percent of students joined the scientific groups to combine clinical and scientific work, and 14.3% solely for research.

Significantly fewer 2nd-year and 5th-year students were involved in research at MUW (8.5% vs 35.2%; $X^2 = 78.95$, df $= 2$, $p < .001$) or outside MUW (3.6% vs 8.2%; $X^2 = 13.38$, df $= 2$, $p = .001$) respectively. Additionally, 23.5% of 5th-year students have published at least one scientific article, 24.0% actively participated (presented an oral or poster presentation) in a scientific conference in Poland, and only 2.4% abroad. Approximately one-third of students in both groups plan to pursue research activities after graduation. There was a significantly higher interest in obtaining PhD title among 2nd-year in comparison to 5th-year students (57.7% vs 46.8%, $X^2 = 14.94$, df $= 1$, $p = .005$). Same differences were seen in terms of participation in international exchanges or internships (88.1% vs 69.8%, $X^2 = 38.48$, df $= 1$, $p < .001$) (Table 2).

Students who had higher scientific interests and participated in the Olympiads in high school were more often involved in research projects at university (24.7% vs 17.5%, $X^2 = 9.28$, df $= 1$, $p = .044$), more often participated in scientific groups (80.3% vs 71.9%, $X^2 = 6.26$, df $= 1$, $p = .01$), and showed higher interest in pursuing a research career after graduation (37.9% vs 28.9%, $X^2 = 7.50$, df $= 2$, $p = .02$). We have not found significant differences between men and women regarding scientific

Table 1. Characteristics of overall study population and responders from the 2nd and 5th year.

	n (%)			
Factor	Overall	2nd-year students	5th-year students	*p*-Value
Gender				
Male	230 (35.1%)	129 (36.5%)	101 (33.3%)	.412
Female	426 (64.9%)	224 (63.5%)	202 (66.7%)	
High school location				
Village	17 (2.6%)	11 (3.0%)	6 (2.0%)	.831
City < 50k inhabitants	127 (19.4%)	69 (19.1%)	58 (19.8%)	
City < 100k inhabitants	89 (13.6%)	51 (14.1%)	38 (13.0%)	
City > 100k inhabitants	421 (64.4%)	230 (63.7%)	191 (65.2%)	
Availability of extracurricular activities in high school	467 (71.6%)	255 (70.8%)	212 (72.6%)	.662
Participation in National Olympiads for high-school students	292 (44.8%)	137 (38.2%)	155 (52.9%)	**<.001**
Laureates of National Olympiads	38 (5.8%)	13 (3.6%)	25 (8.5%)	**<.001**
Research interest in high school				
High	383 (55.2%)	227 (58.2%)	156 (51.3%)	.101
Average	262(37.8%)	141 (36.2%)	121 (39.8%)	
Low	49 (7.1%)	22 (5.6%)	27 (8.9%)	
Considering research possibilities at medical university				
Yes	350 (50.7%)	230 (59.4%)	120 (39.5%)	**<.001**
No	180 (26.0%)	70 (18.1%)	110 (36.2%)	
Hard to say	161 (23.3%)	87 (22.5%)	74 (24.3%)	

Table 2. Comparisons of attitudes regarding research interests, activities, and plans for further scientific career among 2nd and 5th-year students.

	n (%)			
Factor	Overall	2nd-year students	5th-year students	*p*-Value
Member of student scientific group	516 (74.7)	267 (69.0%)	249 (81.9%)	**<.001**
Member of student scientific group on 1st year	39 (5.7%)	23 (6.0%)	16 (5.3%)	.742
Motivation for scientific group activity				
Research	55 (11.7)	34 (14.3)	21 (9.0)	.052
Clinical work	239 (50.9)	124 (52.3)	115 (49.4)	
Clinical work and research	164 (34.9)	71 (30.0)	93 (39.9)	
Other	12 (2.6)	8 (3.4)	4 (1.7)	
Involvement in research projects at the university?				
Yes				
No, but I wish	140 (20.2)	33 (8.5)	107 (35.2)	**<.001**
No	278 (40.2)	190 (49.0)	88 (28.9)	
	274 (39.6)	165 (42.5)	109 (35.9)	
Involvement in research projects outside the university?				
Yes	39 (5.6)	14 (3.6)	25 (8.2)	**.001**
No, but I wish	199 (28.7)	129 (33.2)	70 (23.0)	
No	455 (65.7)	246 (63.2)	209 (68.8)	
Authorship of publication	87 (12.7)	16 (4.2)	71 (23.5%)	**<.001**
Active participation in scientific conference in Poland	89 (12.9)	16 (4.1)	73 (24.0)	**<.001**
Active participation in scientific conference abroad	9 (1.4)	2 (0.6)	7 (32.4)	.163
Plans a research activity after studies				
Yes	233 (33.8)	135 (35.0%)	98 (32.3%)	**.034**
Not know	388 (56.3)	223 (57.8%)	165 (54.5)	
No	68 (9.9)	28 (7.3%)	40 (13.2)	
High interest in obtaining PhD ("Yes" and "definitely yes")	360 (52.8)	218 (57.7)	142 (46.8)	**.005**
High interest in internships/exchanges abroad ("Yes" and "definitely yes")	545 (79.9)	333 (88.1)	212 (69.8)	**<.001**

interests (34.3% vs 34.6%, $X^2 = 3.47$, df = 2, $p = .177$) or involvement in research activities (16.5% vs 22.8%, $X^2 = 3.92$, df = 2, $p = .141$).

Students, who were involved in scientific activities, where asked to rate the difficulty of combining research and studies on a scale from 1 to 5 (1 – very easy, 5-very hard). The mean score was $3.55 + 1.0$ with no significant differences between 2nd and 5th-year students, $3.36 + 1.0$, and $3.76 + 0.98$, respectively. We asked students to rate how their research activity is perceived by the university environment (colleagues, teachers) on a scale from 1 to 5 (1 – very negative, 5-very positive) and found that 5th-year students are perceived more positively than 2nd-year students ($3.4 + 1.05$ vs $3.72 + 1.03$; $p = .002$).

Responders were also asked if the information about the possibilities of scientific activity is properly promoted at our university. 23.2% of 2nd-year students and 37.9% of 5th-year students have answered that it is not appropriately promoted ($p < .001$). 5th-year students more often stated that current scientific reports are covered during the classes (67.7% vs 47.9%, $X^2 = 17.78$, df = 2, $p < .001$) and more often evaluated the attitude of lecturers as demotivating for scientific activity (25.2% vs 14.5%, $X^2 = 25.35$, df = 2, $p < .001$).

Opinions on scientific issues

Students were asked to rate the importance of ten statements about research on the Likert scale from 1 to 5 (1 – strongly disagree, 5 – strongly agree) (Table 3). There were no differences between 2nd and 5th-year students in 3 issues and significant differences in 7 ($p < .05$, Table 3). Respectively, 33.1% and 21.9% of 2nd and 5th-year students, agree that every student should take part in scientific research during their studies. Similarly, 55.0% of 2nd-year and 37.3% of 5th-year students agree that a medical student should be able to plan, conduct a research project, and write a scientific publication. Detailed rates of agreement with each statement are presented in Table 3.

Barriers to scientific work at university

The most important barriers to scientific work at university among 2nd-year students were lack of time, lack of knowledge on how to start, and lack of resources/funding. The lack of knowledge on how to start, lack of time, and lack of experience were the most common in the group of 5th-year students (Table 4). Five of 13 potential barriers were differently perceived between 2nd and 5th-year students ($p < .05$, Table 4). Detailed rates of agreement with each potential barrier are presented in Table 4. We have not found significant differences in perception of obstacles depending on gender, scientific interests in high school, participation in Olympiads, or involvement in university research projects.

Table 3. Comparisons of attitudes regarding selected issues associated with research among 2nd and 5th-year students.

	Agreement* from 2nd-year students (%)	Agreement* from 5th-year students (%)	p**
Science allows us to better understand the world	90.8	97.0	.220
We're living healthier and safer with science	88.6	86.1	.212
Every doctor, dentist, pharmacist should know the basis of scientific research	78.4	75.6	.719
Research is important because it develops logical thinking and the ability to deduce	75.8	65.0	**.000**
Every student should take part in scientific research during their studies	33.1	21.9	**<.001**
A medical student should be able to plan and conduct a research project and write a scientific publication	55.0	37.3	**<.001**
Conducting research is important to be a good specialist (clinician) in a given medical field	47.6	22.1	**<.001**
The methodology of conducting scientific research should be taught at university.	63.4	73.3	**.005**
I trust the results of research presented by the public (TV, press)	12.7	5.9	**<.001**
I trust the research results presented in the scientific journals	76.9	89.4	**<.001**

*Responses 4 and 5 on a 5-point Likert scale were grouped as "agreement" for reporting purposes.
**U-Mann–Whitney test between responses of 5-point Likert scale.

Table 4. Comparisons of attitudes regarding barriers for research during medical studies among 2nd and 5th-year students.

Barrier	Agreement* from 2nd-year students (%)	Agreement* from 5th-year students (%)	p**
Lack of time	82.2	81.4	.750
Lack of knowledge of how to start	76.5	88.3	**<.001**
Lack of funding/grants for research	73.6	73.4	.994
Lack of knowledge on the subject	70.2	73.8	.099
Lack of experience	70.1	77.6	**.006**
More interest in clinical than scientific work	68.0	66.3	.500
No idea/research team	62.0	70.5	**.015**
Greater emphasis on education than science/research	63.8	63.8	.919
Lack of substantive preparation in terms of researching during the studies	57.6	69.2	**<.001**
Lack of information on scientific work opportunities	58.4	61.1	.202
Lack/insufficient financial compensation	52.1	51.0	.693
Fear of making mistakes	53.8	38.8	**<.001**
Discouragement of assistants/teachers/colleagues	32.1	33.7	.590

*Responses 4 and 5 on a 5-point Likert scale were grouped as "agreement" for reporting purposes.
**U-Mann–Whitney test between responses of 5-point Likert scale.

Discussion

Medicine and research are inevitably connected – a better understanding of human physiology and pathophysiology drives advances in therapy, leading to improved patient survival and quality of life. The involvement of physicians in the research activities provides appropriate bench-to-bedside translation of results. On the other side, physicians who pursue mainly clinical work require some scientific background to provide the best care, based on the recent research findings and current state of the art. Medical schools and universities should provide medical adepts with the knowledge and skills required for work as physicians. However, they seem to be also the optimal place to stimulate the research activity of students and motivate them to become involved in medical research. Teaching the basics of research methodology or interpreting medical publications should be obligatorily included in the curriculum.

We have conducted one of the first surveys assessing attitudes of Polish medical students towards research and examined their involvement in scientific activities during the study period. Similar studies have been previously conducted in other countries [9–18].

Students' involvement in research activities

We have found that the majority of students are involved in the activities of students' scientific groups. It is important to underline that such groups provide research opportunities and possibilities, such as participation in clinical shifts or surgeries, for broadening

clinical knowledge and skills. Nearly half of the students declared that research is one of the reasons for their involvement in scientific groups, but only a few of them participated in the scientific activities during their 1st year at university. This discrepancy shows significant room for improvement in opening research opportunities for medical students from the beginning of their presence at university to accommodate their needs and interests in science.

Over 30% of 5th-year students were involved in scientific projects, and almost a quarter has published at least one research article. That suggests that student-run projects are recognised by medical journals. Rates of students involved in research projects and medical journal publications are similar to those reported in a previous studies [12,15,18,20,21] or even higher [13,14,16,17]. Besides journal publications, active participation in scientific meetings is another way to disseminate research results. In our study, students presented their results at scientific conferences in Poland, but only a few showed them abroad. An appropriate support system should be applied to promote participation at international meetings and increase students' competitiveness in the international arena.

Plans for future involvement in research

We have found that one-third of students consider the research activities after graduation. The proportion seems lower compared to other studies from Poland or Brazil, where 50–60% students have declared so [13,22]; however, the reporting bias may significantly affect the results. We lack data about the exact number of students who pursue their research career after university in Poland. Still, considering the statistics from the US [2,3], where only 1.5% of graduates are scientifically active, the proportion observed in our study is promising. Offering structured research training during studies or the introduction of MD-PhD programs could improve this rate since other data from the US suggest that 60% of MD-PhD holders are now in full-time academic faculty roles, and 77% remain active in research [23].

Factors affecting/influencing students' research activities

We have tried to find if any factors influence students' research activities. We have looked at their interests in research issues in high school and found that over 50% of students declared a high interest. Generally, it is assumed that high-school students with the highest scientific interests are more willing to participate in various competitions, including National Olympiads for High-School Students. Over 40% of MUW students have participated in the Olympiads, confirming their high interest. Despite high scientific interests in high school, only a low proportion of students choose medical studies solely for research opportunities. On the other side, approximately half of the students consider research opportunities when selecting a medical school. These data are promising; however, they need to be prospectively evaluated.

Importantly, students who present high scientific interests before enrolment to the university are more often involved in scientific projects and interested in a further career in this area. Similar findings were also reported in the Netherlands, where participants of pre-university research courses were 2–3-times more involved in research and scientific publishing [24]. Also, in the US or Canada, higher participation in MD-PhD Programmes and scientific activities is observed among graduates of medical colleges than those from general high schools [9]. Candidates applying to medical universities who displayed high scientific interests or achievements in high school could be identified during the admission process to define students who would benefit from tailored, more intensive research training aiming at the complex development of physician-scientists after graduation.

Role of research in medical curriculum

We have observed significant differences between 2nd and 5th-year students regarding their attitude towards the role of research in the medical career. 2nd-year students, more often than 5th-year students, agreed that medical students should be able to plan and conduct research as it is an important skill in becoming a good specialist in a given medical field. These findings are the opposite of what was found in other countries [9,25]. This discrepancy may result from a different attitude of students who have recently joined the university or from the change of attitudes during their studies. Considering that almost 25% of 5th-year students assessed the attitude of lecturers at the university as demotivating for scientific activity, the second reason seems more probable. We plan a prospective study on 2nd-year students to verify this hypothesis and determine how their attitudes will change during the studies.

Multiple studies have shown that research methodology courses early in the curriculum can increase

students' interest in pursuing a research career [25–27]. Most offered courses are project-based, while only around 20% are coursework only [28]. About 10–40% of students, depending on the course, have published the results of their projects in peer-reviewed journals, which is more than in our study [28]. Dyrbye et al. also showed that students that conducted a research project during the course produced more non-related research within three years of graduation [29].

Another approach to strengthen students' research interests was implemented in some countries. For example, The Medical Student Research Programme in Norway has led to an increase in the recruitment of graduated physicians to medical research [30]. Similar findings were also reported for other courses [28,31]. Moreover, it has been shown that finding a devoted and passionate mentor is a well-described factor that improves student participation in research [9,32]. Our survey did not include questions about mentors, which consists one of this study's limitations.

Barriers to participation in research

Several barriers can limit students' participation in research. Lack of time and knowledge on starting a research career were found to be the most common issues in our study, which is consistent with previous reports [9,15–17]. Combining research and studies is perceived as more difficult by our study population than by students from Sweden [17]. Moreover, most students agree, as previously described elsewhere [12,15–17,21], that lack of experience and appropriate research training at the university are important limiting factors. Based on those results, it seems that changes in the curricula of medical universities should be introduced to decrease the workload, give students more time and opportunities for participation in elective courses and other activities (including conducting research projects). A wider variety of classes and training in research methodology should be offered. Information on scientific opportunities should also be better promoted since half of the students consider it a significant barrier. Over one-third of 5th-year students responded that such possibilities are not appropriately promoted.

Another obstacle to carrying out a successful research project are financial issues. Lack of grants and funding for student-run projects is a significant barrier, according to almost 75% of students, which is consistent with available data [12,15,17]. Interestingly, insufficient financial compensations are essential only for half of the responders. It is worth underlining that previous studies reported lower salaries for clinicians working in research than clinics, especially in the private sector [1,33]. These inequities should also be tackled to eliminate the financial barriers to research opportunities.

Limitations of the study

Despite providing an interesting insight into the attitudes of Polish medical students towards research, our study poses several limitations. First, it was conducted as a self-reported questionnaire; thus, reporting and recall bias could affect the results, especially in 5th-year students who were asked to evaluate their high school interests. Additionally, the population represents medical students, not including dentistry or physiotherapy students, of only one medical faculty from over 15 medical faculties in Poland. Even though we have compared students at the beginning of their university career (2nd-year) with more advanced ones (5th-year), a prospective study assessing how attitudes change during the studies would better characterise the influence of the university on students' attitudes towards research. Comparisons between 2nd and 5th-year students should be interpreted with caution since differences in background exposure may cause significant differences between both groups. The results could also be affected by differences in the degree to which an individual matures between the end of high school and the fifth year of medical school, but this issue was not evaluated in this study. There was a higher proportion of female participants (64.9%), limiting the replicability of our findings in other populations; however, this percentage is in line with the ratio of female medical students in Poland. Moreover, we have not observed any significant differences in attitudes towards research between male and female students. Lastly, comparisons with other countries presented in the discussion section must be interpreted with caution. Differences in the education system can highly affect students' attitudes and opinions towards research.

Conclusions

Our results showed a generally positive attitude regarding research among medical students. A significant proportion of students are already involved in research and willing to continue this career path; however, many students do not present such interests. The role of medical schools in promoting research

activities among their students should be broadly discussed. Due to the shortage of physicians-scientists, urgent action to modify medical curricula and extend the research methodology courses and provide students with opportunities to conduct research is needed. On the other side, most countries face a shortage of healthcare workers, and universities have to place much interest and resources into the practical training of future physicians. Whether medical universities should focus on practical medical education, concentrate on research and scientific training, or combine both issues remains open.

Considering a variety of attitudes, probably the "one-size-fits-all" model of medical school is not appropriate to allocate both clinical and research priorities. Some students could be identified early as more likely to participate in medical research, like those with previous research experience, participation in scientific competitions, or previous graduate degree work. We propose that dedicated curricula for students with higher scientific interests should be offered at every stage of medical university, starting from the very beginning of the first year. Motivation systems, such as scholarships and international exchanges, should be offered to those conducting high-quality research to extend their opportunities in the research labour market after graduation. The attention should be also put to the students who are not interested in research to provide them with the basics of methodology and scientific publishing that might be useful in their clinical career. The available evidence shows that such courses can change students' attitudes towards research [25].

Ethics approval and consent to participate

According to the national regulations and noninterventional character of the study, ethical approval was not required [19]. The verbal informed consent was obtained from all study participants, what is a standard procedure in this type of noninterventional study according to national regulation [19].

Authors' contributions

PS designed the study, prepared the survey, performed statistical analyses and wrote the main manuscript text. JD reviewed and distributed the survey, collected data and wrote the main manuscript text. NB reviewed and distributed the survey, and collected data. MK reviewed and distributed the survey, and collected data. ZZ reviewed and distributed the survey, and collected data. LP prepared the questionnaire, distributed questionnaires, and collected data. DMG designed the study, reviewed the survey and analysed data. ACJ designed the study, reviewed the survey, analysed data and supervised the study. All authors reviewed and agreed to the published version of the manuscript.

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Data availability statement

The datasets generated during and analysed during the current study are not publicly available due to institutional regulations but are available from the corresponding author on reasonable request.

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